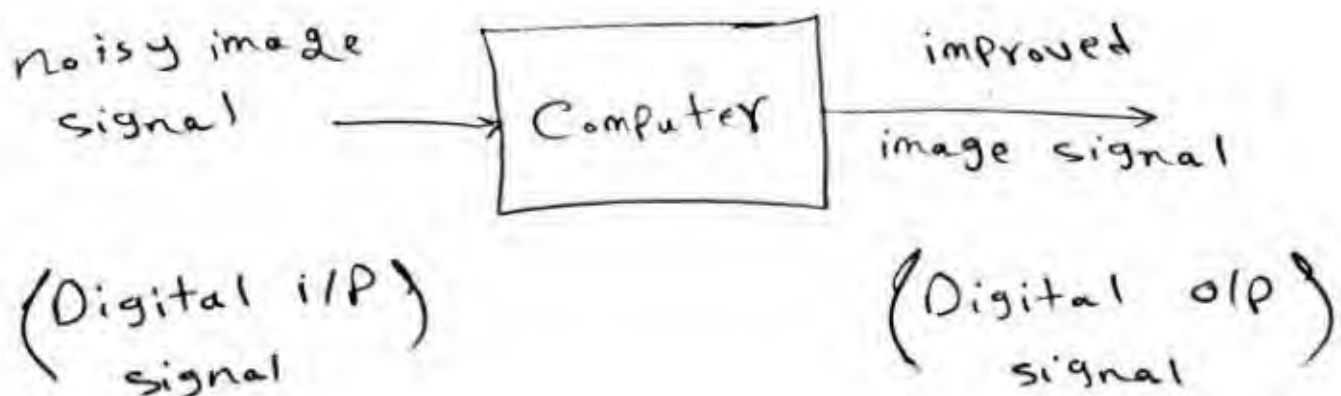
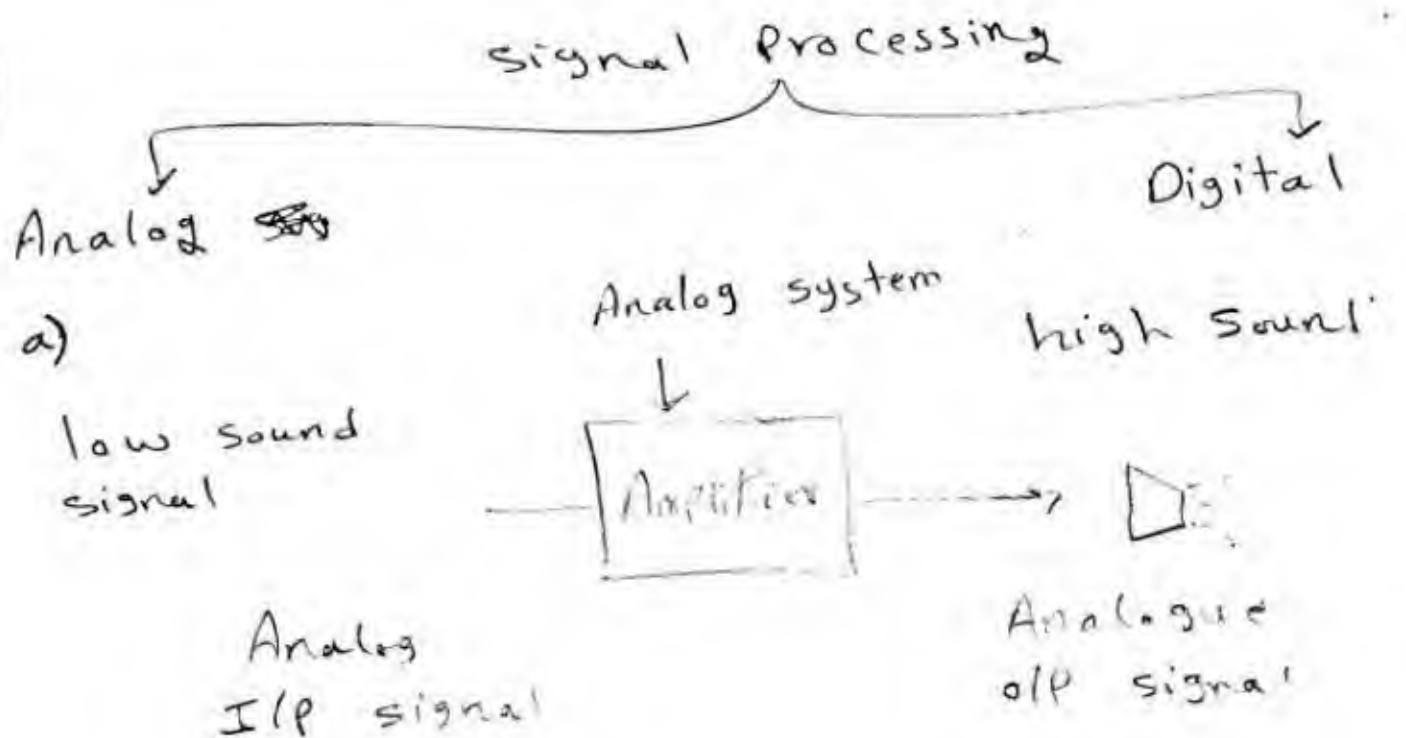


Digital Signal Processing

"DSP"



Digital

→ Advantage of Dsp

- ① more Flexible.
- ② more Accurate.
- ③ easy to store.
- ④ easy to update.

* The Basic of Dsp

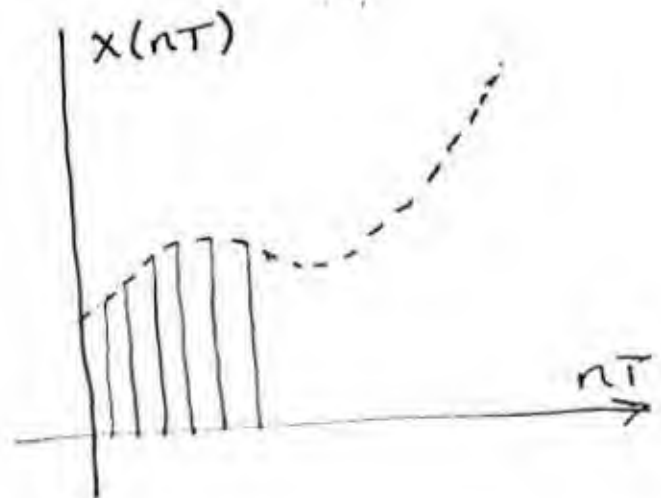
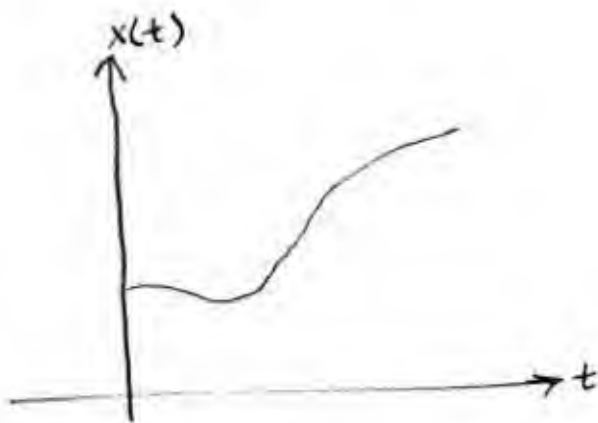


A/D → Analog to Digital Converter.

D/A → Digital to Analog Converter.

A/D ≡ Sampler

Analog \times Digital



$T \Rightarrow$ Sampling time

$n \Rightarrow$ Sampling no. ($n=0,1,2,3,4,\dots$)

↑ عدد العينات

← (Sampler) كذا زاد فزيد عدد التقاطع ~~من~~
 دقة التقاطع ~~تزداد~~ وتزيد الدقة (Accuracy)
 ولكن ~~تحتاج~~ إمكانات أعلى.

~~Assume~~ $T=1$

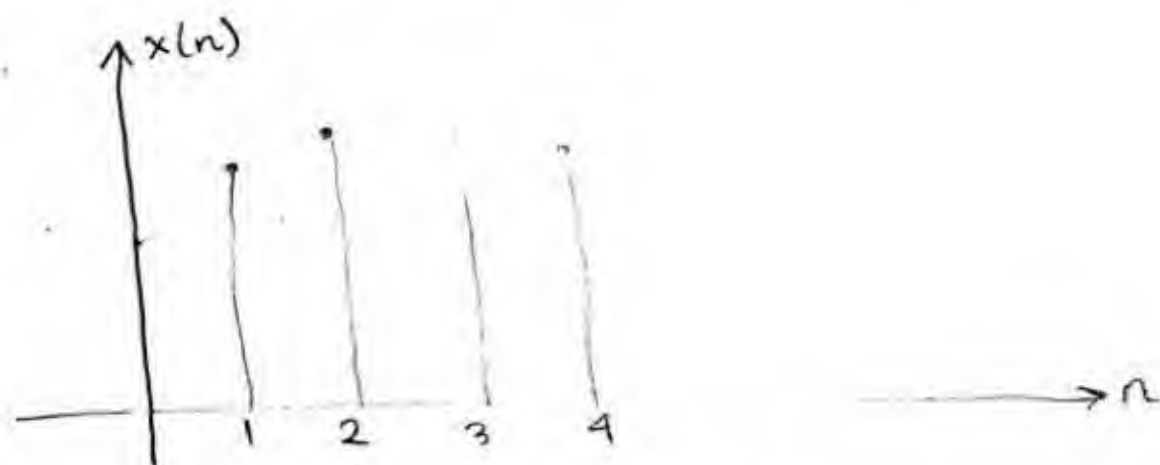
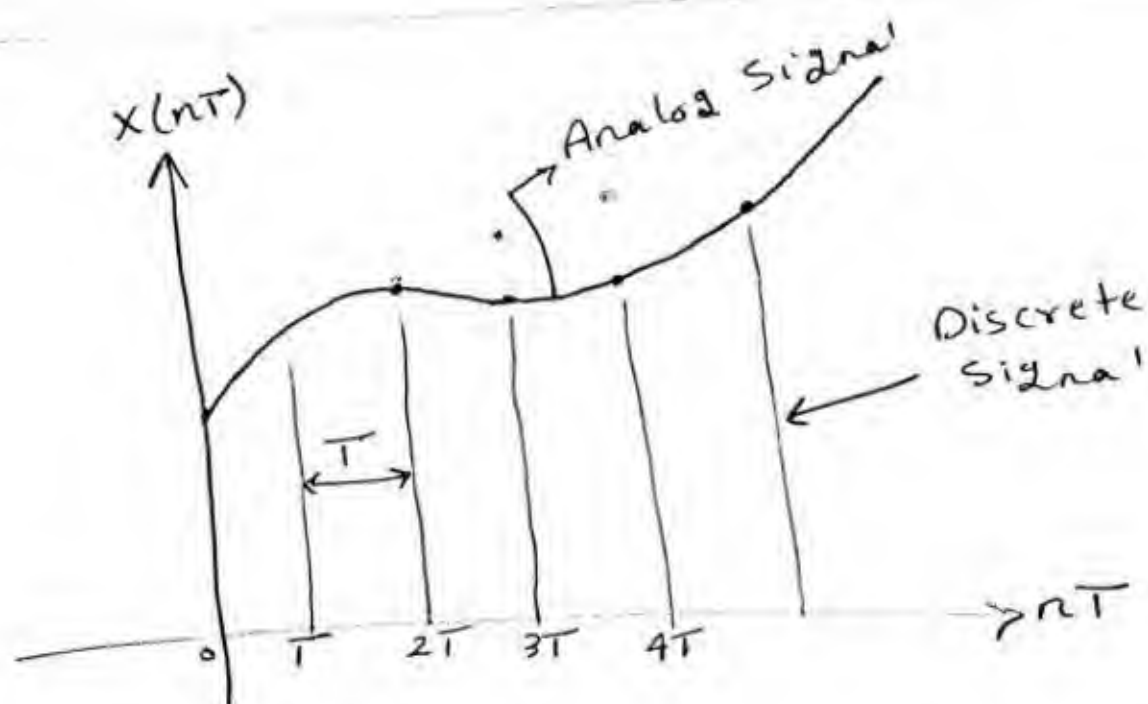
→ Assume $T=1$

$$x(nT) = x(t) \Big|_{t=nT}$$

at: $T=1$

$$\bullet x(n) = x(t) \Big|_{t=n}$$

↑ Sampling no.



* Common discrete signals (sequences)

① unit sample signal (impulse)

$$\delta(n) = \begin{cases} 1 & n = 0 \\ 0 & \text{otherwise} \end{cases}$$



$$\delta(n) = \{ \dots, 0, 0, 0, 1, 0, 0, 0, \dots \}$$

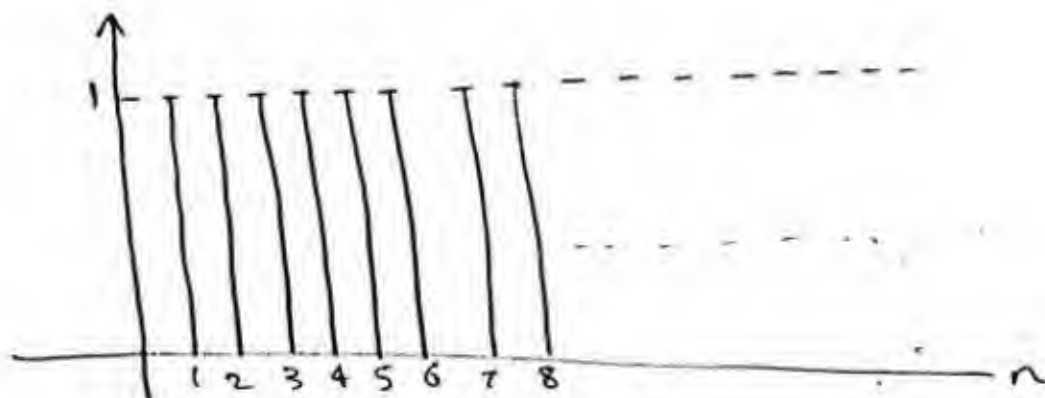
↑

← معروف انه السهم ده يعرفه δ (n=0) والارقام على يمينها تكون $\{ \dots, 3, 2, 1 \}$ وعلى اليسار بالسالب $\{ \dots, -2, -1 \}$

↑ \Rightarrow indicate $n=0$

② unit step signal

$$u(n) = \begin{cases} 1 & n \geq 0 \\ 0 & \text{otherwise} \end{cases}$$



$$u(n) = \{ \dots, 0, 0, 0, 1, 1, 1, 1, 1, 1, \dots \}$$

↑
 $n=0$

$$= \{ 1, 1, 1, \dots \}$$

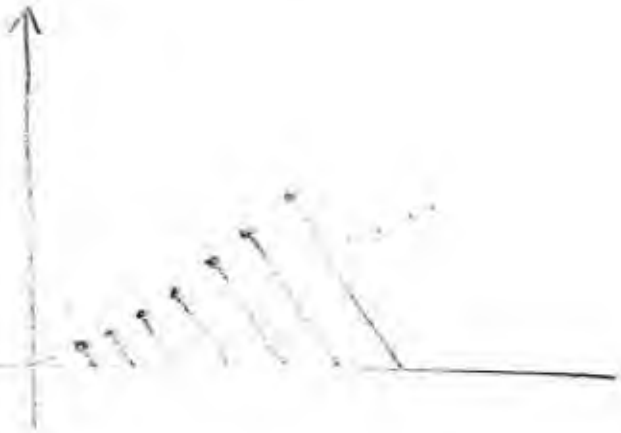
↑
 $n=0$

③ unit ramp signal:-

$$u_r(n) = \begin{cases} n & n \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

$$u_r(n) = \{ 0, 1, 2, 3, 4, \dots \}$$

↑
 $n=0$

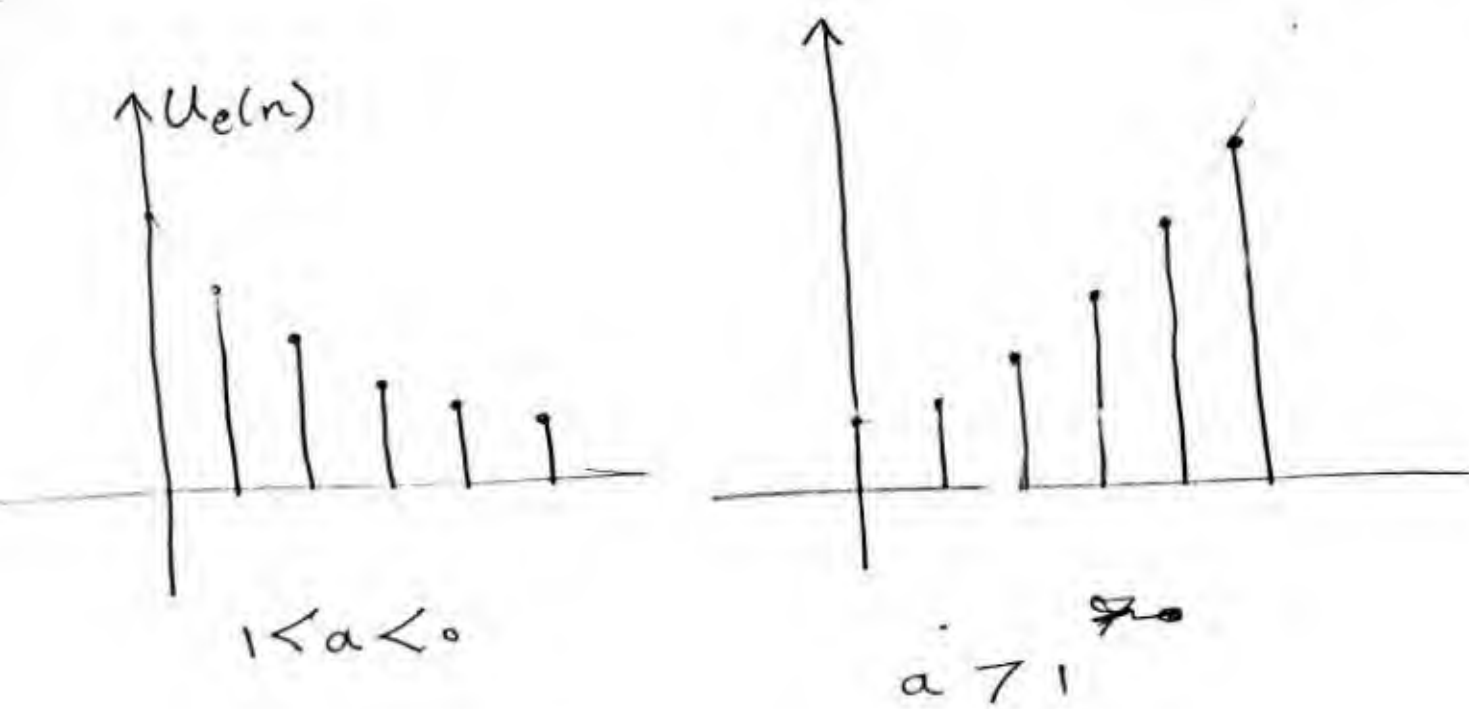


④ exponential signal:-

$$u_e(n) = \begin{cases} a^n & n \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

$$u_e(n) = \{ 1, a, a^2, a^3, \dots \}$$

↑
 $n=0$



Ex:- Given the following sequence:-

$$x(n) = \left\{ \frac{1}{3}, \frac{1}{2}, -1, 0, 1, \dots, 2 \right\}$$

$\uparrow \quad \uparrow \quad \uparrow \quad \uparrow$
 $n=-1 \quad n=0 \quad n=1 \quad n=2$

(a) sketch $x(n)$

(b) Find $x(1), x(2), x(3), \{x(-1), x(-2), x(-3), x(-4)\}$

Sol

$$x(1) = 1$$

$$x(-1) = 0$$

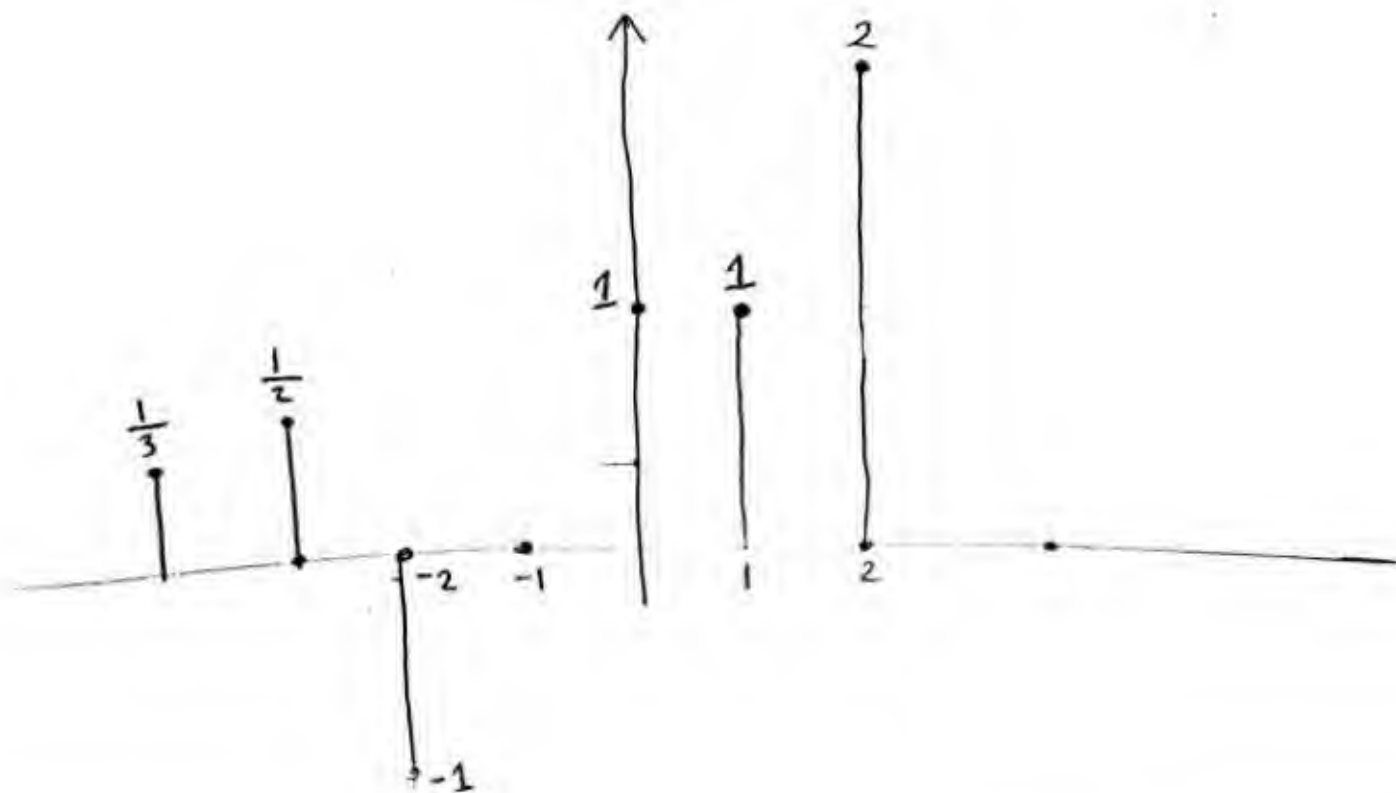
$$x(2) = 2$$

$$x(-2) = -1$$

$$x(3) = 0$$

$$x(-3) = \frac{1}{2}$$

$$x(-4) = \frac{1}{3}$$



Ex find $\sum_{k=-\infty}^n \delta(k)$

$$\sum_{k=-\infty}^n \delta(k) = \dots + \delta(-2) + \delta(-1) + \delta(0) + \delta(1) + \dots + \delta(n)$$

$$\left. \begin{array}{l} n=0 \Rightarrow x(0)=1 \\ n=1 \Rightarrow x(1)=1 \\ n=2 \Rightarrow x(2)=1 \end{array} \right\} \Rightarrow x(n) = \sum_{k=-\infty}^n \delta(k) = u(n)$$

↳ unit-step

8

Ex

Find $x(n) = \sum_{k=0}^{\infty} \delta(n-k)$

$$x(n) = \delta(n) + \delta(n-1) + \delta(n-2) + \dots$$

Notice

$$\delta(n) = 1 \mid n=0$$

$$\delta(n-1) = 1 \mid n=1$$

$$\delta(n-2) = 1 \mid n=2$$

you can consider it

unit step

$$x(n) = u(n)$$

→ The main operations on discrete signals:-

① shifting operation (delay, Advance)

② Folding (reflection) operation.

③ Add operation.

④ multiplication operation

g

EX $x(n) = \{1, 1, 1, 1\}$

Find $y_1(n) = x(-n)$ & $y_2(n) = x(n-1)$

$y_3(n) = x(n+1)$ & $y_4(n) = 2x(n)$

$y_5(n) = x(n-1) + x(n+1)$



1 $y_1(n) = x(-n)$

$n=0 \Rightarrow y_1(0) = x(0) = 1$

$n=1 \Rightarrow y_1(1) = x(-1) = 0$

$n=2 \Rightarrow y_1(2) = x(-2) = 0$

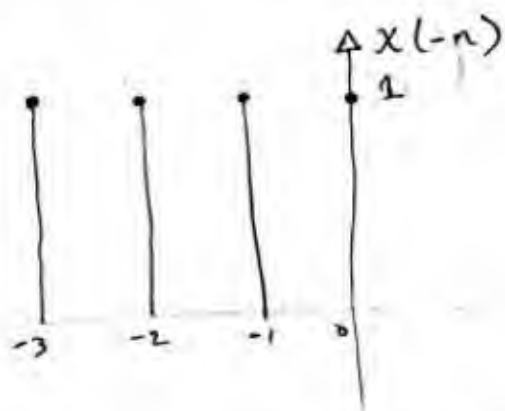
$n=-1 \Rightarrow y_1(-1) = x(1) = 1$

$n=-2 \Rightarrow y_1(-2) = x(2) = 1$

$n=-3 \Rightarrow y_1(-3) = x(3) = 1$

$n=-4 \Rightarrow y_1(-4) = x(4) = 0$

مفیش داعی ٲکمل ٲذا الباقی بأصفر



→ It is a folding operation.

$$\textcircled{b} \quad y_2(n) = x(n-1)$$

$$n=0 \Rightarrow y_2(0) = x(-1) = 0 \quad \left| \quad n=-1 \Rightarrow y_2(-1) = x_2(-2) = 0$$

$$n=1 \Rightarrow y_2(1) = x(0) = 1$$

$$n=-2 \Rightarrow y_2(-2) = x_2(-3) = 0$$

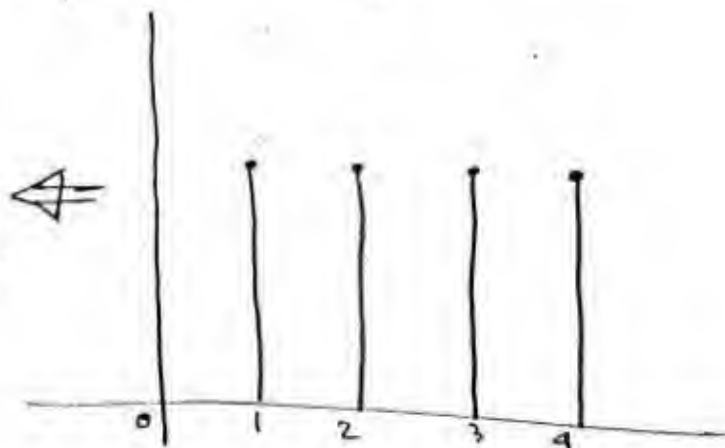
$$n=2 \Rightarrow y_2(2) = x(1) = 1$$

$$n=3 \Rightarrow y_2(3) = x(2) = 1$$

$$n=4 \Rightarrow y_2(4) = x(3) = 1$$

$$n=5 \Rightarrow y_2(5) = x(4) = 0$$

Shift to right by
one sample
↓

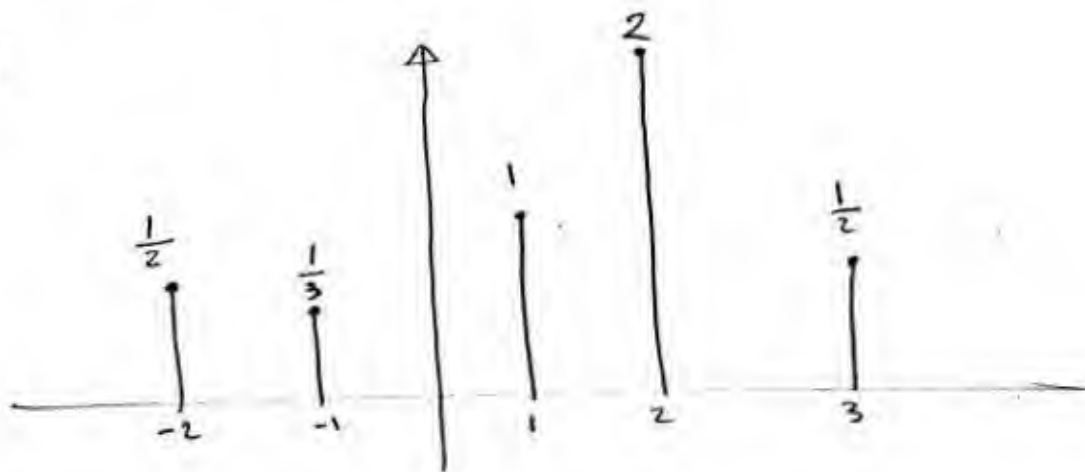


Delay operation
(Delay by one sample)

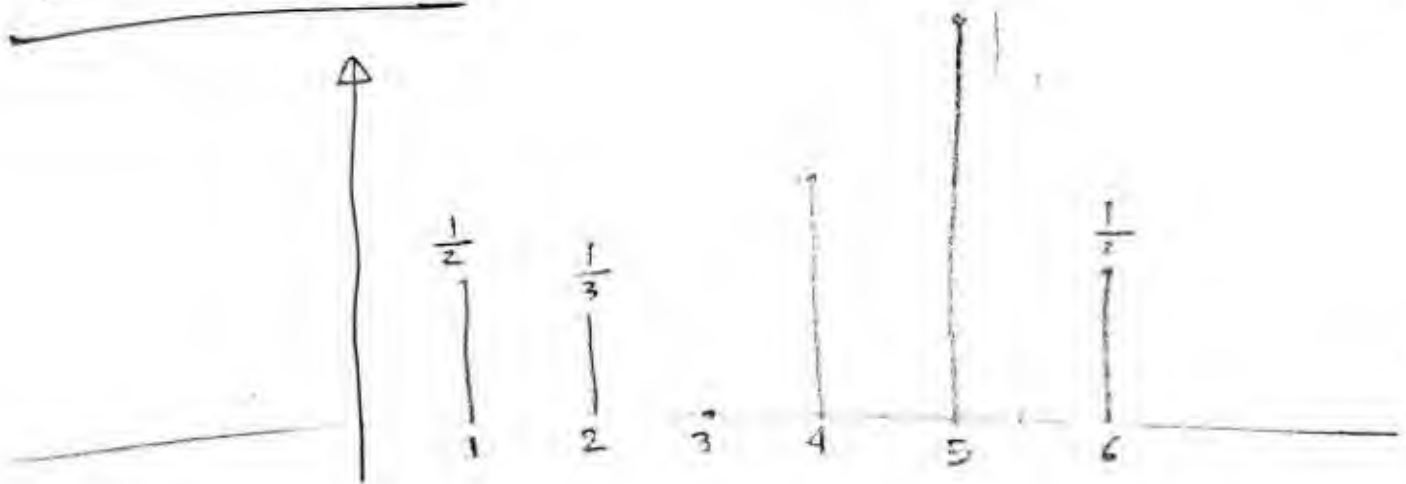


$x(n-k) \Rightarrow$ shift to right by k -samples.

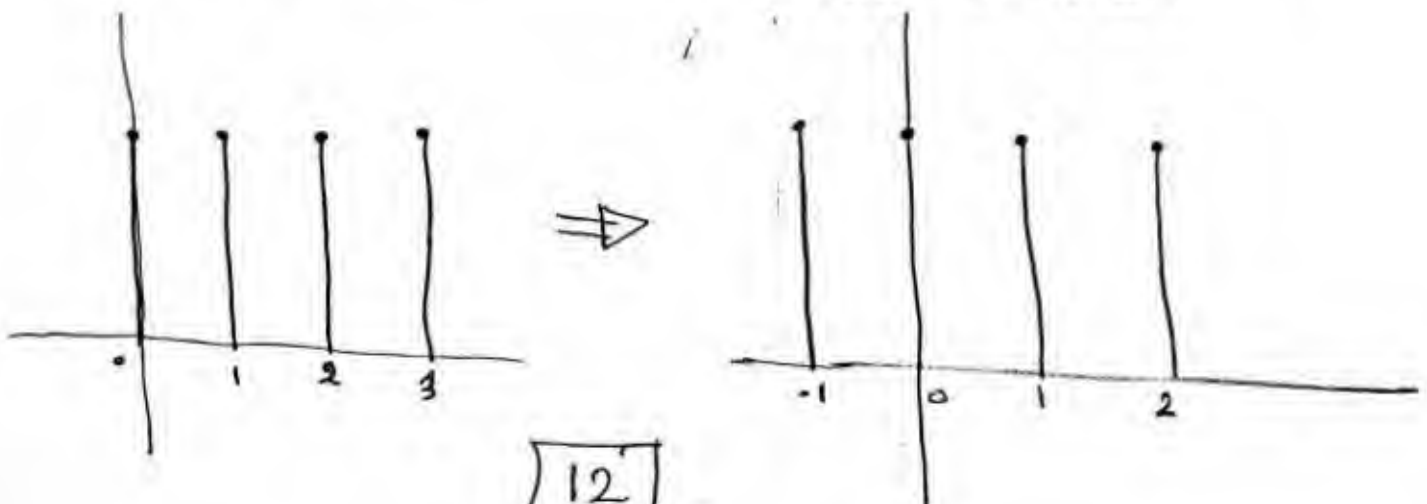
EX



Find $x(n-3)$

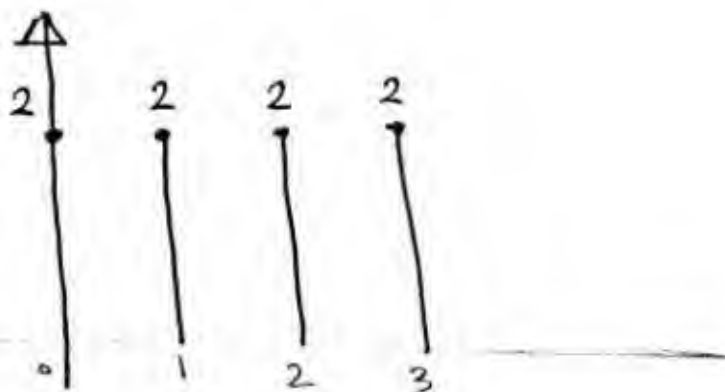


③ $y_3(n) = x(n+1) \rightarrow$ shift to left by one sample.



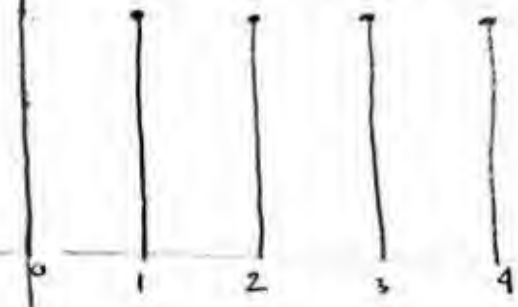
$x(n+k) \rightarrow$ shift to left by k -samples.

④ $y_4(n) = 2x(n)$

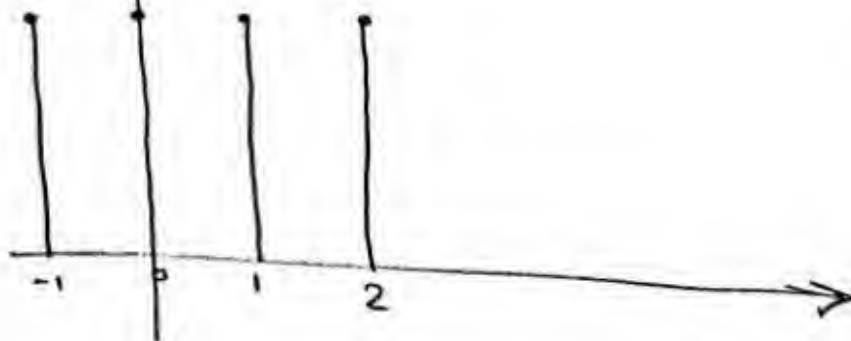


⑤ $y_5(n) = x(n+1) + x(n-1)$

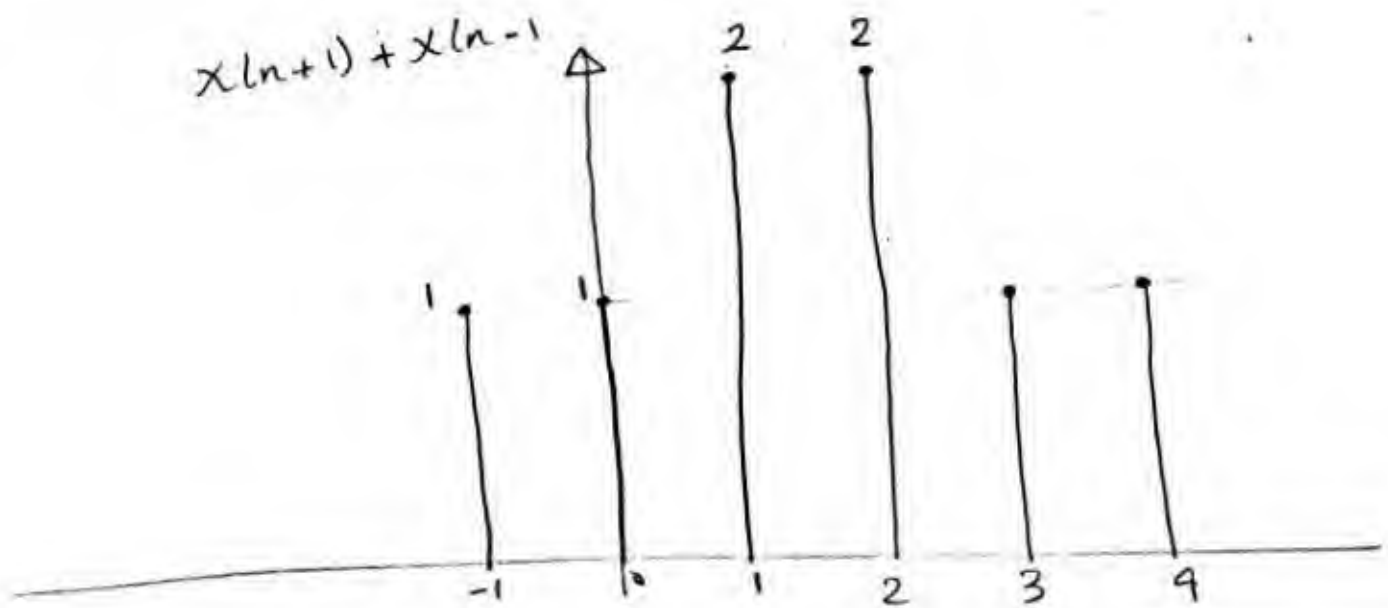
$x(n-1)$



$x(n+1)$



$$x(n+1) + x(n-1)$$

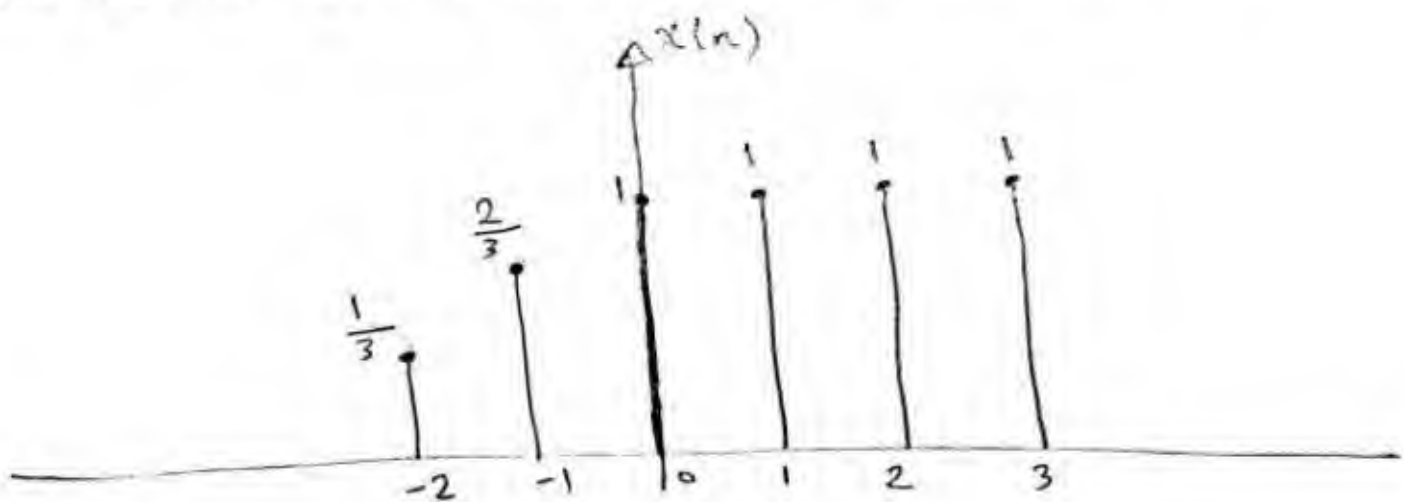


EX $x(n) = \left\{ \frac{1}{3}, \frac{2}{3}, 1, 1, 1, 1 \right\}$

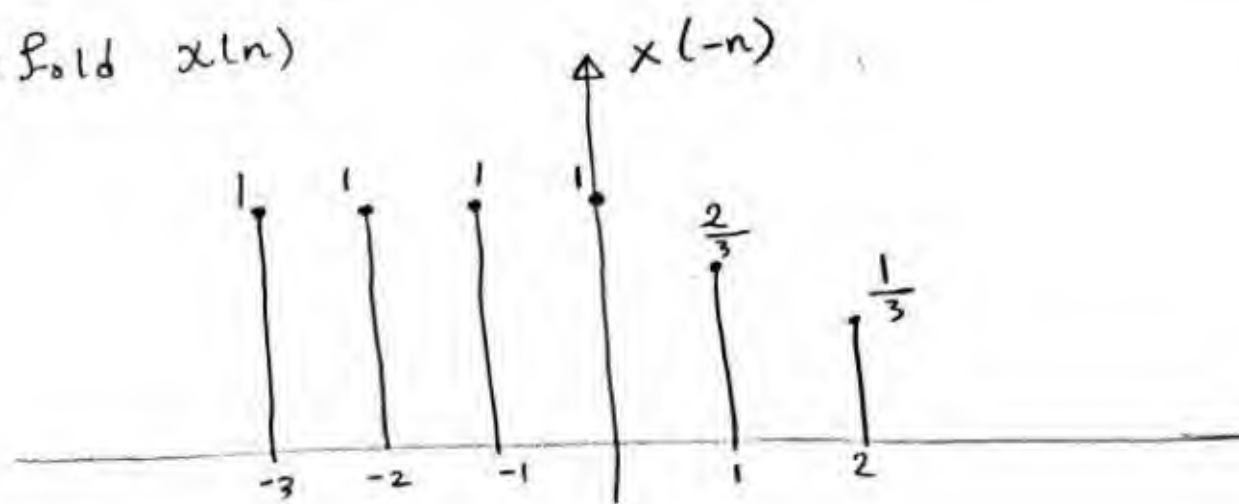
1- sketch $x(n)$

2- Fold $x(n)$ and then delay by 4 samples.

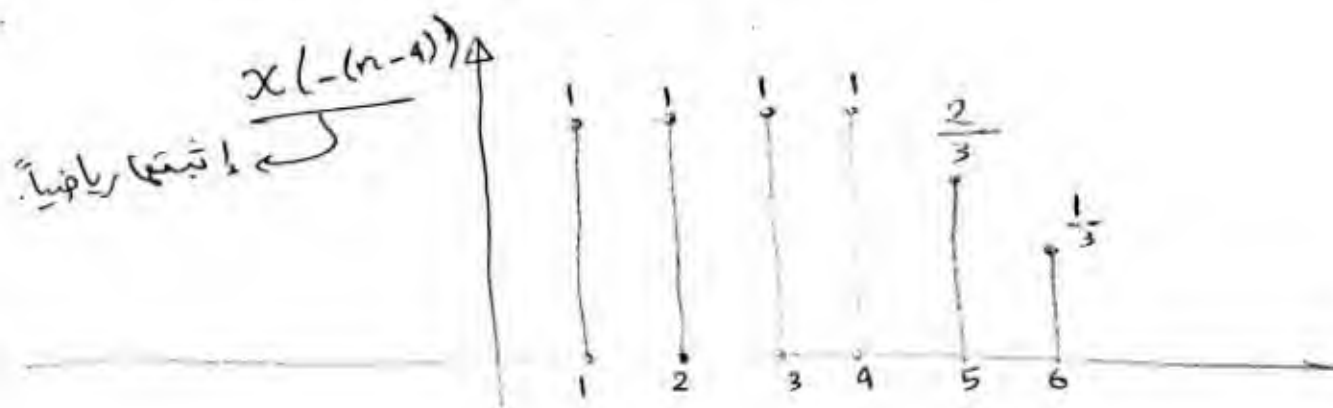
3- Delay $x(n)$ by 4 samples then Fold.



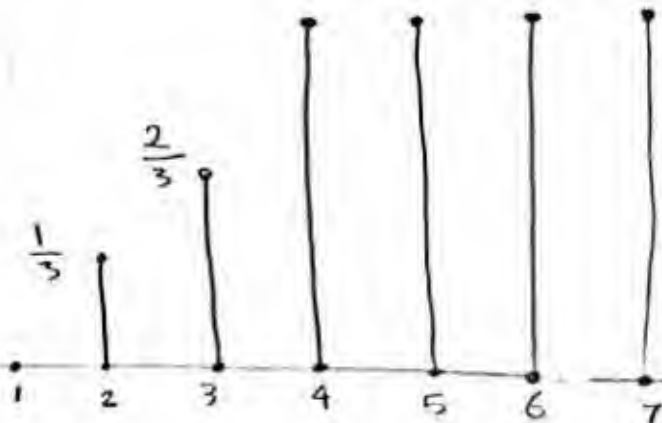
2) Fold $x(n)$



Delay by 4-samples.



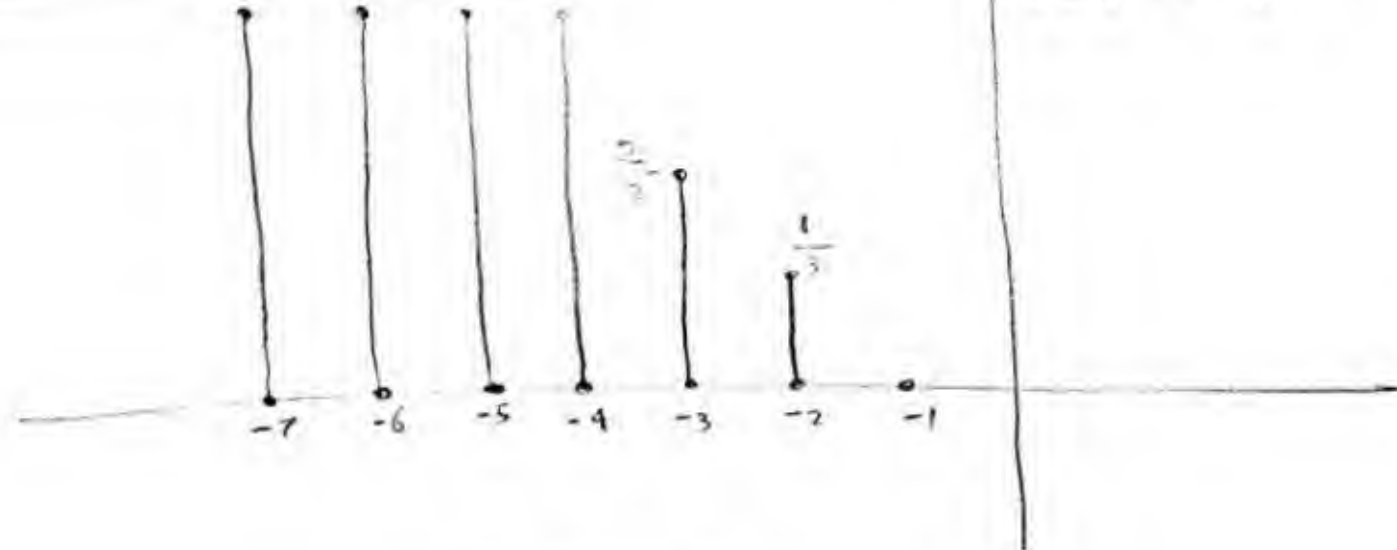
$x(n-4)$



~~Delay by 4-sample~~

→ Then Fold :-

$x(-n-4)$



[16]